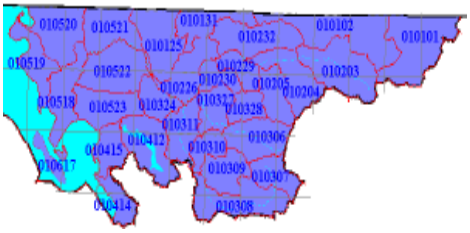

Nooksack River Pilot Assessment

Nooksack River - WRIA 1

Overview

The Nooksack River Basin (WRIA 01) is the northern most basin in the SSHIAP project area. The watershed drains 826 square miles and contains approximately 1,325 miles of stream. The majority of the watershed lies within Whatcom County, however forty-nine square miles of the watershed are located within British Columbia. The small remaining portion of the watershed lies within Skagit County.

There are 12 stocks of salmon or steelhead identified by SASSI (WDF&W and NWIFC 1992) as utilizing the Nooksack River system. Of these twelve stocks, two are considered "healthy", two "critical", and eight "unknown" (Table 1).

The Nooksack River is managed principally for natural production of all stocks. Hatchery facilities within the basin include the Bellingham Hatchery, the Nooksack or Kendall Creek Hatchery, and the Lummi or Skookum Creek Hatchery.

Geographic description

The watershed consists of four major sub-basins, the North Fork, South Fork, Middle Fork, and mainstem Nooksack. In addition to the Nooksack River, there are a number of smaller independent drainage's within WRIA 01.

The North Fork Nooksack River drains an area of approximately 293 square miles, 4.9 of which are within British Columbia. The North Fork heads on the north slopes of Mt. Shuksan and flows westerly for approximately 40 miles to the confluence with the South Fork near the town of Deming. Over this distance, the North Fork descends from elevations of near 3300 feet to an elevation of 300 feet at Deming.

The Middle Fork drains an area of about 102 sq. mi. It heads on the south side of Mt. Baker near an elevation of 4000 feet and flows westerly 17 miles to the confluence with the North Fork at an elevation of slightly over 300 feet.

The South Fork heads on the southeast slopes of Twin Sisters Mountain at an elevation of approximately. 3100 feet. It flows first southerly, then westerly and finally northerly to the confluence with the North Fork near Deming, encircling Twin Sisters Mountain. The total length of the South Fork is about 36 miles and the drainage area is approximately 182 square miles.

The mainstem Nooksack River below Deming flows westerly and southerly from an elevation of 300 feet to it's entry to Puget Sound at Bellingham and Lummi Bays.

Geology

The geology of the Nooksack River Basin is diverse. The basin is generally underlain by granite, granodiorite, and quartz diorite (Alt & Hyndman, 1994). As with many Puget Sound watersheds, much of the lower Nooksack River basin is mantled with consolidated glacial till. In many areas, this till is relatively impermeable to water and results in the presence of poorly drained soils and wetland areas. Outwash and recessional deposits occur in many areas of the watershed, particularly along the former margins of the Puget glacier . These are generally unconsolidated, well drained, and unstable. Lacustrine deposits, formed in lakes created by obstruction of higher elevation valleys by the Puget glacier, are found in many mid-elevation valleys. These deposits are also generally poorly drained and may be highly unstable. Above approximately 1600 feet

Table 1. Salmon and Steelhead Stocks within the Nooksack River basin (WRIA 1).

Species	Stock	Status	Stock Origin	Production Type
Chinook	North Fork Nooksack	Critical	Native	Composite
	South Fork Nooksack	Critical	Native	Wild
	Samish/Mainstem Nooksack	Unknown	Non-Native	Composite
Fall Chum	North Fork Nooksack	Healthy	Native	Wild
	Mainstem/South Fork	Unknown	Native	Wild
	Samish/Independent	Healthy	Mixed	Composite
Coho	Nooksack	Unknown	Mixed	Composite
	Samish	Healthy	Mixed	Composite
	North Puget Sound Tributaries	Unknown	Mixed	Wild
Pink	North Fork/Middle Fork	Unknown	Mixed	Wild
	South Fork Nooksack	Unknown	Native	Wild
Summer Steelhead	South Fork Nooksack	Unknown	Native	Wild
Winter Steelhead	Dakota Creek	Unknown	Native	Wild
	Mainstem North Fork	Unknown	Native	Wild
	South Fork Nooksack	Unknown	Native	Wild
	Middle Fork Nooksack	Unknown	Native	Wild
	Samish	Depressed	Native	Wild

elevation, native bedrock dominates, however much of this area has also been worked by glacial action and localized glacial deposits exist.

Hydrology

The Nooksack River drains the North Cascade Mountains including Mt. Baker. Much of the total annual discharge of the river is produced by snow-melt and glacial runoff. Peak flows occur principally during fall, winter, and spring months. Low summer flows generally occur in late summer and early fall, although high summer flows may be experienced in glacially fed streams.. The mean annual discharge for the mainstem Nooksack River is approximately 4,099 cfs at Ferndale.

Within the Nooksack basin, there are three distinct streamflow and runoff regimes (Dept. of Conservation, 1960). These three regimes represent those streams fed primarily by glacier melt, streams whose headwaters lie in the higher elevations of the Cascade mountains and fed by snow-melt and precipitation, and lowland streams fed primarily by storm runoff. Glacial fed streams often experience peak flows during summer months during periods of maximum glacial melt. Snowmelt fed streams often experience maximum streamflow during spring months although may experience high flows during winter rain-on-snow events. Lowland streams experience maximum flows during winter months, coincident with times of maximum precipitation.

The lower Nooksack consists of two main historical channels, the mainstem and the Lummi River. Currently essentially all of the flow is carried by the mainstem channel and flows to Bellingham Bay. Prior to 1860 however, the river flowed principally down the Lummi River into Lummi Bay. The diversion to Bellingham Bay was reportedly originally caused by a log jam, however a permanent dam/dike was later constructed (USGS 1960).

Precipitation within the basin ranges from an average of thirty inches per year at Bellingham to approximately 140 inches per year near Mt. Baker. Precipitation above 1700 feet elevation during winter months falls primarily as snow. A number of large glaciers on and around Mt. Baker supply a year round source of surface runoff, accounting for the relatively high seven-day low flow.

Land cover / Land use

Land use within Whatcom County, and the Nooksack basin in particular, is dominated by forestry and agriculture, although recent trends in population growth indicate an increasing conversion from these uses to urban, residential, and commercial. Of a total of 486,195 acres within the basin, approximately 81,454 acres are in crop or rangeland, 388,784 acres in forest land, 5,972 acres in rural non-agricultural, and 4,364 acres in urban/suburban development.

Population

Whatcom County is currently the ninth most populous county in Washington State with a population of 148,300 in 1995. It is also one of the fastest growing counties in the state. Population growth in the County has been almost constant since its creation in 1854 (Figure 1). The population is almost evenly split between unincorporated (47%) and incorporated areas (53%).

Bellingham is the largest municipality within Whatcom County with a population of 57,830 in 1995, ranking as the ninth largest city in Washington. Other incorporated areas within the county include Blaine, Everson, Ferndale, Lynden, Nooksack, and Sumas.

Major industries within the County, in order of the percent total of all jobs, includes manufacturing; services; government; retail trade; construction; wholesale trade; real estate; and agriculture/forestry/fishing.

Salmon and steelhead habitat

Figure 2 shows the lengths (miles) and distribution of anadromous habitat within, and tributary to, the mainstem Nooksack River. Habitats are categorized as either large tributary or small

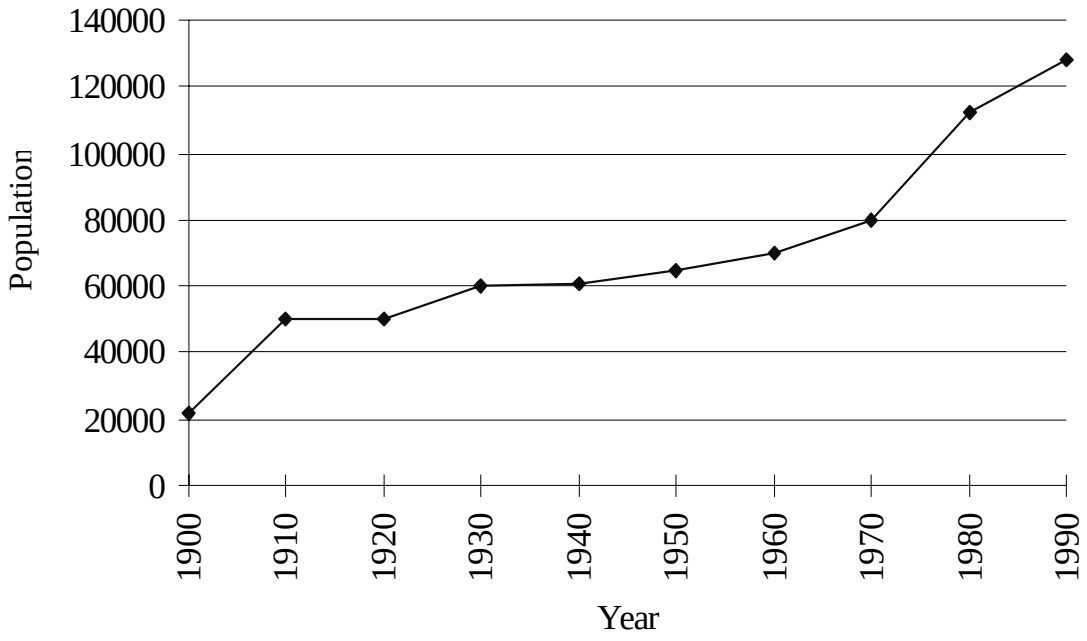

Figure 1. Whatcom County Population from 1900 to 1990.

tributary habitat as defined by Beechie et al. (1995). Lengths of habitat are totaled by the location of their confluence with the mainstem Nooksack from the mouth (RM 0) to the confluence of the mainstem and the North Fork (RM 36). As can be seen in Figure 2, most of the available habitat in the lower basin is small tributary with a total length of 203.5 miles, as compared to approximately 34 miles of large tributary habitat.. There are three major areas of available small tributary habitat, between RM's 0-3, RM's 9 to 12, and RM's 24 to 27.

North Fork anadromous habitat locations and lengths are shown in Figure 3. Only large and small tributary habitats are found along the North Fork. Small tributary habitat is generally more abundant than large tributary habitat. A barrier falls at RM 24 blocks access to upper portions of the North Fork, and thus habitat types above this point are not indicated. There are two areas along the North Fork that provide much of the small tributary habitat - between RM's 3 and 6, and between RM's 12 and 18. In total, there are approximately 106 miles of small tributary habitat and 23 miles of large tributary habitat available to anadromous salmonids in the North Fork system.

Habitat availability and distribution for the Middle Fork Nooksack are depicted in Figure 4. Within this sub-basin, there are approximately 17.4 miles of large tributary habitat, 52 miles of small tributary, and 1 mile of side channel habitat. A major man-made dam at RM 7.2 blocks access to suitable habitat above this point.

Totals of large tributary, small tributary, and side channels for the South Fork Nooksack are shown in Figure 5. As with the other areas within the Nooksack drainage, the lengths of available small tributary habitat are much greater than either large tributary habitat or side channels. Side channel habitat was found at only two locations, between RM's 9 and 12, and between RM's 30 and 33. Total estimated lengths of habitat within the South Fork system are 188.5 miles of small tributary, and 40.1 miles of large tributary.

Habitat loss

Loss of habitat from obstructions such as blocking culverts, dikes, and dams are depicted in Figure 6 for the estuary areas along the Lummi River, and the mainstem Nooksack River below the confluence with the Lummi River. Close to 60 miles of small

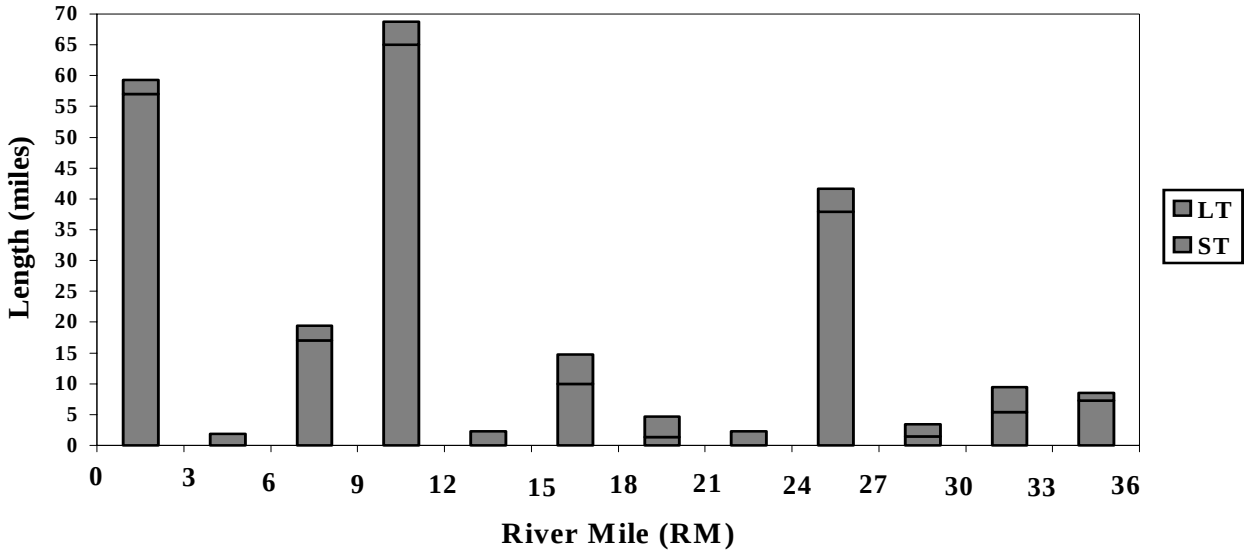

Figure 2. Total miles of large and small tributary habitat within the Nooksack River basin. Habitats are catagorized as small tributary (ST), large tributary (LT), and side channel sloughs (SC).

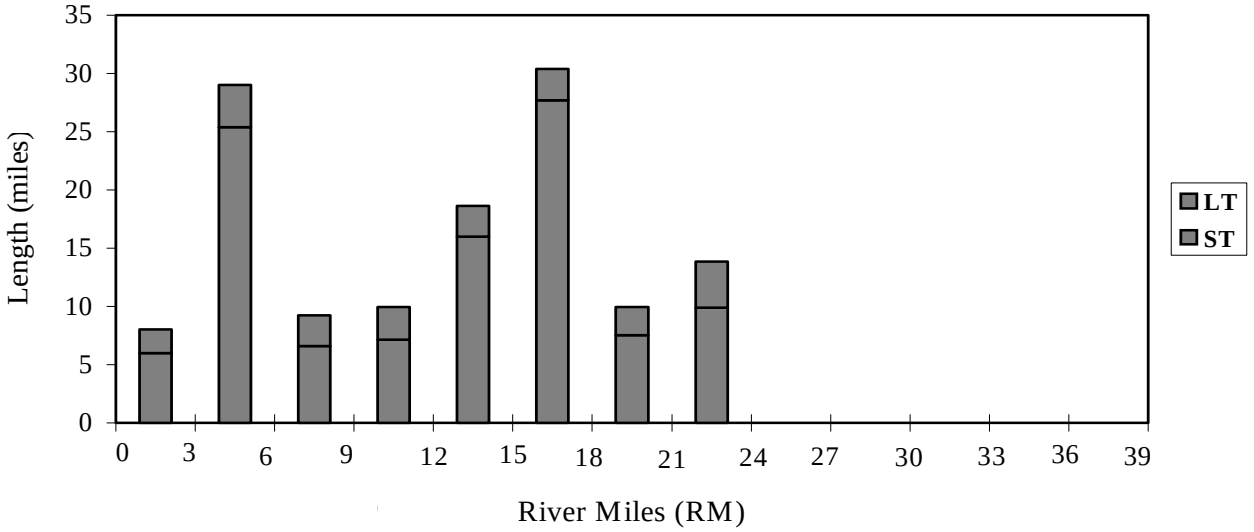

Figure 3. Total miles of large and small tributary habitat within the North Fork sub-basin. Habitats are catagorized as small tributary (ST), large tributary (LT), and side channel sloughs (SC).

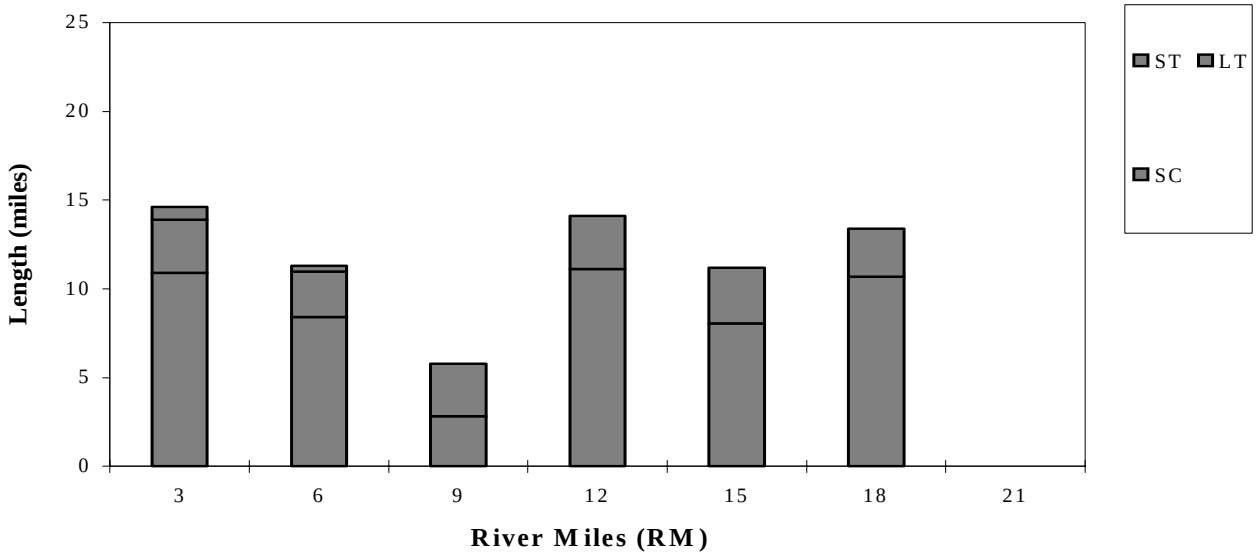

Figure 4. Total available anadromous habitat within the Middle Fork sub-basin. Habitats are catagorized as small tributary (ST), large tributary (LT), and side channel sloughs (SC).

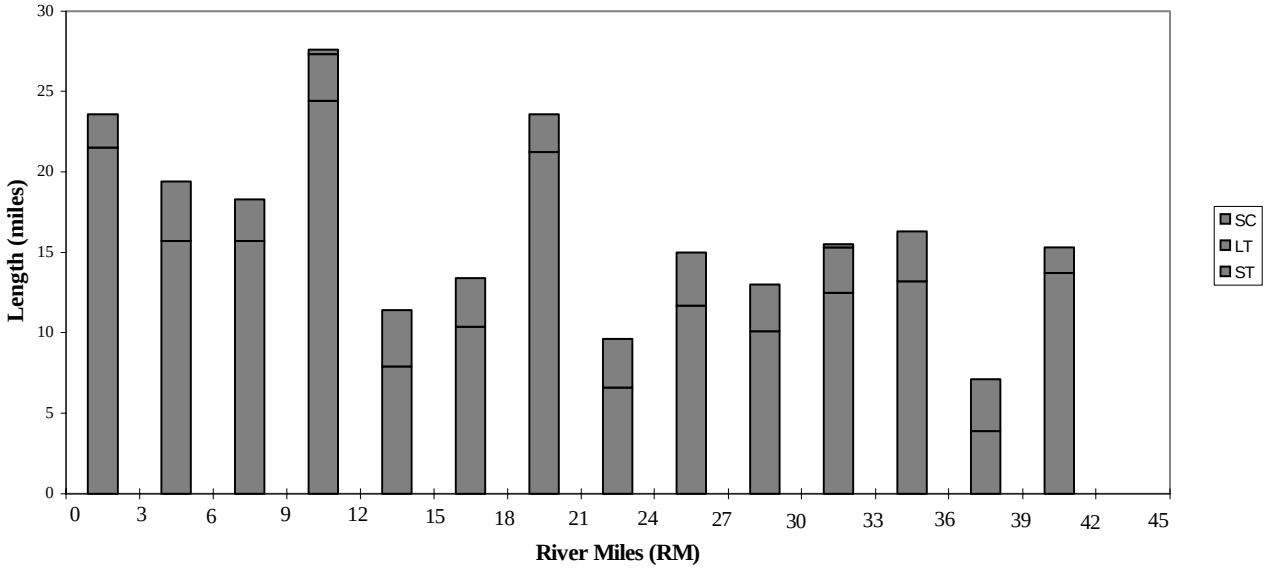

Figure 5. Total available anadromous fish habitat within the South Fork Nooksack sub-basin. Habitats are catagorized as small tributary (ST), large tributary (LT), and side channel sloughs (SC).

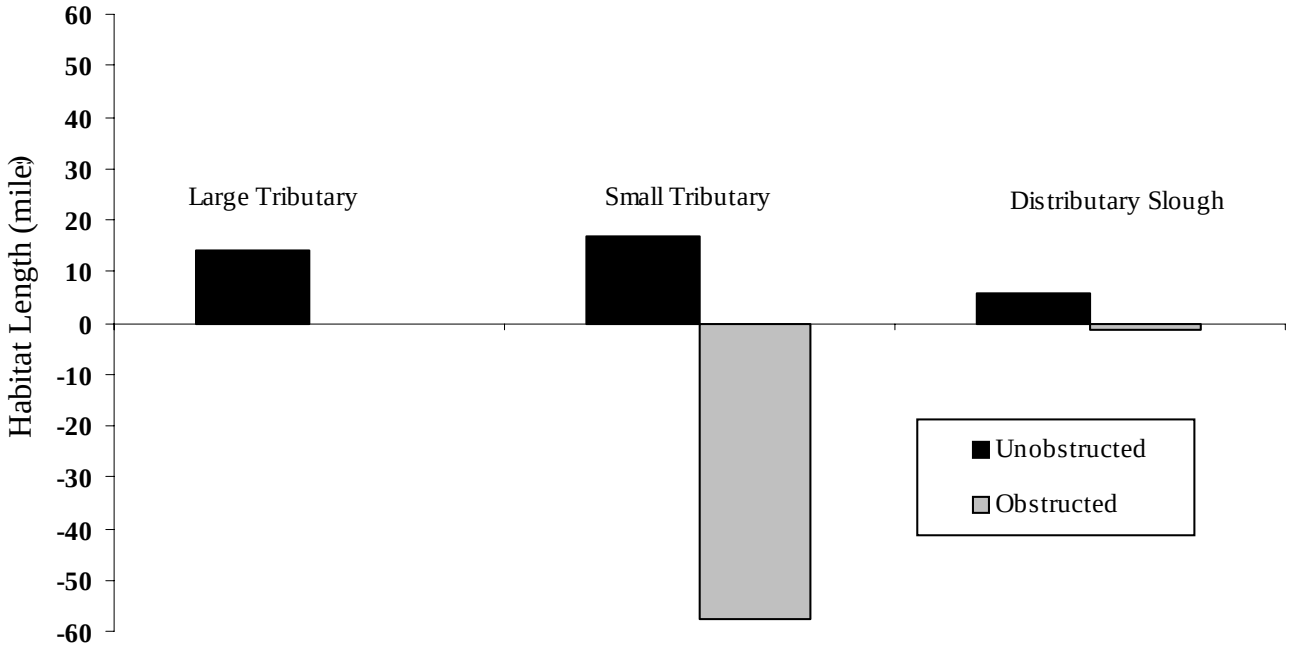

Figure 6. Total miles of large and small tributary habitat within the Nooksack estuary below the confluence of the Lummi and Nooksack rivers.

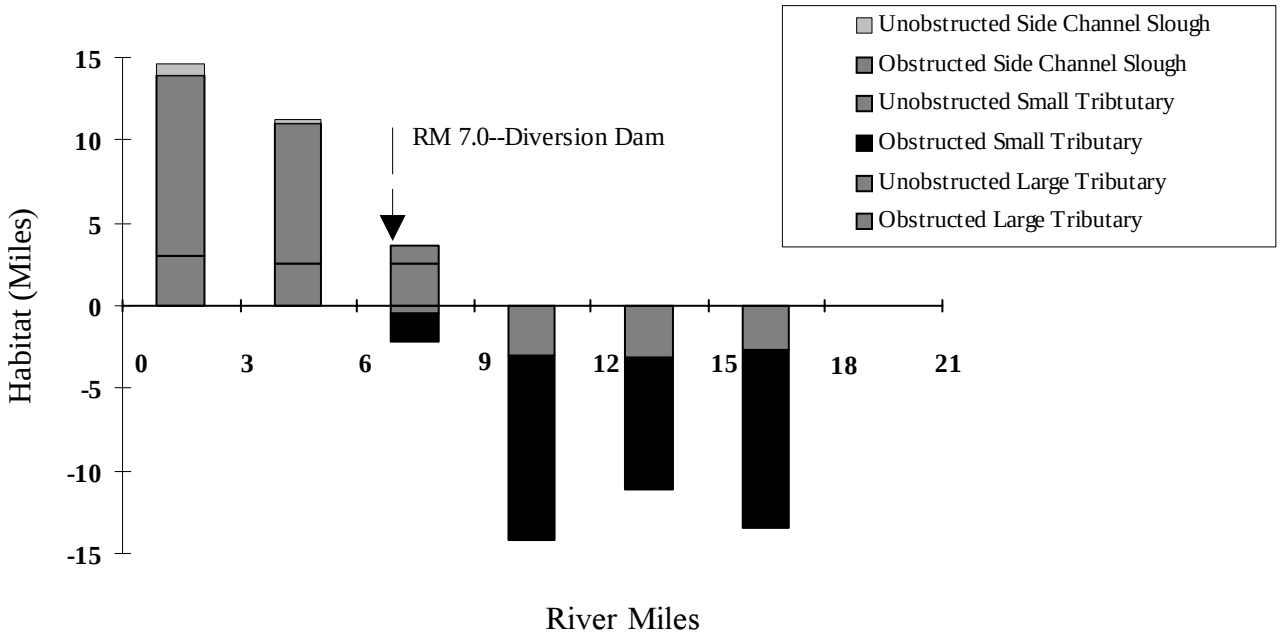

Figure 7. Obstructed Habitat in Middle Fork Nooksack

tributary habitat are obstructed. The amount of obstructed habitat is close to three times the amount of unobstructed small tributary habitat. A little more than one mile of distributary sloughs have been lost due to obstructions. No obstructed mainstem habitat has been identified, however most of the lower river has been diked and heavily modified. The Lummi River is partially obstructed. The point of confluence of the Lummi River and the mainstem Nooksack has been diked and the Lummi River apparently only carries flood waters, therefore access by downstream migrating fish to the Lummi river is limited. The lower end of the Lummi River is not obstructed and is accessible to fish migrating from Lummi Bay into the river.

The Middle Fork Nooksack contains significant amounts of obstructed habitat (Figure 7). A major dam at RM 7.2 blocks access to approximately 31.6 miles of obstructed small tributary habitat and 9.2 miles of large tributary habitat that would otherwise be available to anadromous fish. No side channel habitat was identified as obstructed above RM 7.2.

No significant obstructed habitat was found in either the South Fork or North Fork Nooksack River sub-basins.

Estuarine Habitat

The Nooksack and Lummi rivers are radically changed from their historic condition. As previously noted, the Lummi River was the historic main channel of the lower Nooksack system. The upstream end of the Lummi was reportedly first blocked by a natural log jam, and later by more permanent dikes and flood gates, resulting in the diversion of essentially all flow down the Nooksack River channel. The permanent blockage was constructed in the 1890's.

The diversion of the Lummi River has had several long-term impacts on salmon and steelhead habitat in the Nooksack system. The most obvious is the full or partial obstruction of the mainstem Lummi River, it's tidal channels and distributary sloughs, and a number of small tributary streams. These habitats are obstructed for use by downstream migrants who cannot directly access these areas without first entering Bellingham Bay, migrating to the north, and then entering the Lummi River. It is unlikely that either adult or juvenile salmonids perform this migration as it involves a

fresh-marine-fresh transition. The biological impacts of this obstruction of habitat is likely the reduction of the overall smolt production potential of the lower Nooksack River. The obstruction of the Lummi River has essentially halved the amount of lower river and estuarine habitat that were historically available, and thus has probably halved the production potential of the lower Nooksack system.

An additional impact of the obstruction of the Lummi River is the inability of migrating adults to enter the Nooksack River via the Lummi River, thus eliminating many miles of feeding and transition area. The biological significance of this loss is likely more indirect and would be more difficult to estimate. Upstream migrants that enter the Lummi River and who wish to access the upper reaches of the Nooksack system would be forced to migrate back out the Lummi River, move south to Bellingham Bay, and migrate up the Nooksack channel. Again this would involve a salt-fresh-salt-fresh transition that would be very physiological stressful and may result in increased mortality, reduced spawning performance, etc. It is not known whether this impact is occurring in the Nooksack system.

Wetlands in the lower Nooksack system have also been dramatically altered from historic conditions through diking, dredging, filling, agriculture, urbanization, and industrial development. Bortleson (1979) developed a series of maps of historic and present day wetlands in sixteen Puget Sound estuaries including Bellingham Bay (Figure 8.). Wetlands have been drained and used for agriculture and other land-uses, diked, and filled. Bortleson reported there has been a loss of 1.6m^2 either subaerial or mudflat wetlands in the Lummi and Nooksack river delta areas. The Bortleson data indicates that there has been a 82.8 m^2 loss of subaerial wetland, a 0.5 Km^2 loss of tidal mudflat, and a reduction in shoreline length of 217.6 m^2 in the Lummi River delta. In addition, the much of the wetland habitat is obstructed due to dikes, floodgates, and roads.

Our analysis of the Bortleson maps also indicate a loss of 10.9 mi^2 of subaerial wetland, 46.9 mi^2 loss of mudflat, and an increase in shoreline length of 212.5 miles in the Nooksack delta. Increases in shoreline length are due to Port of Bellingham construction.

The biological effects of these changes are likely again a proportionate loss in the production

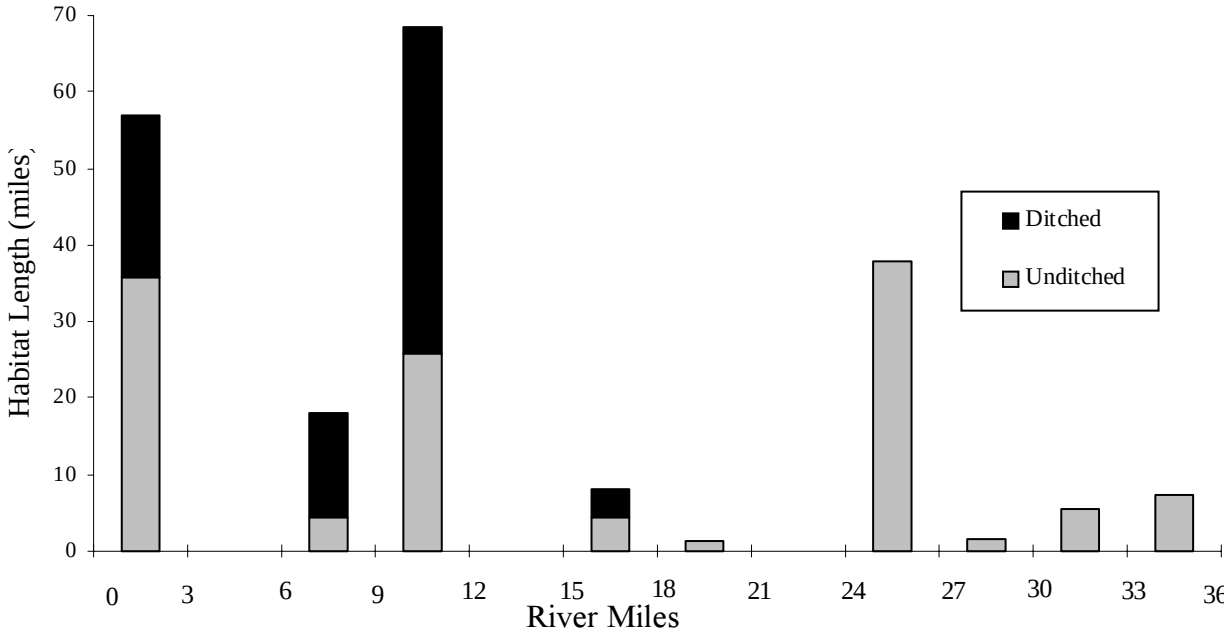

Figure 9. Lengths of ditched and unditched small tributary habitat.

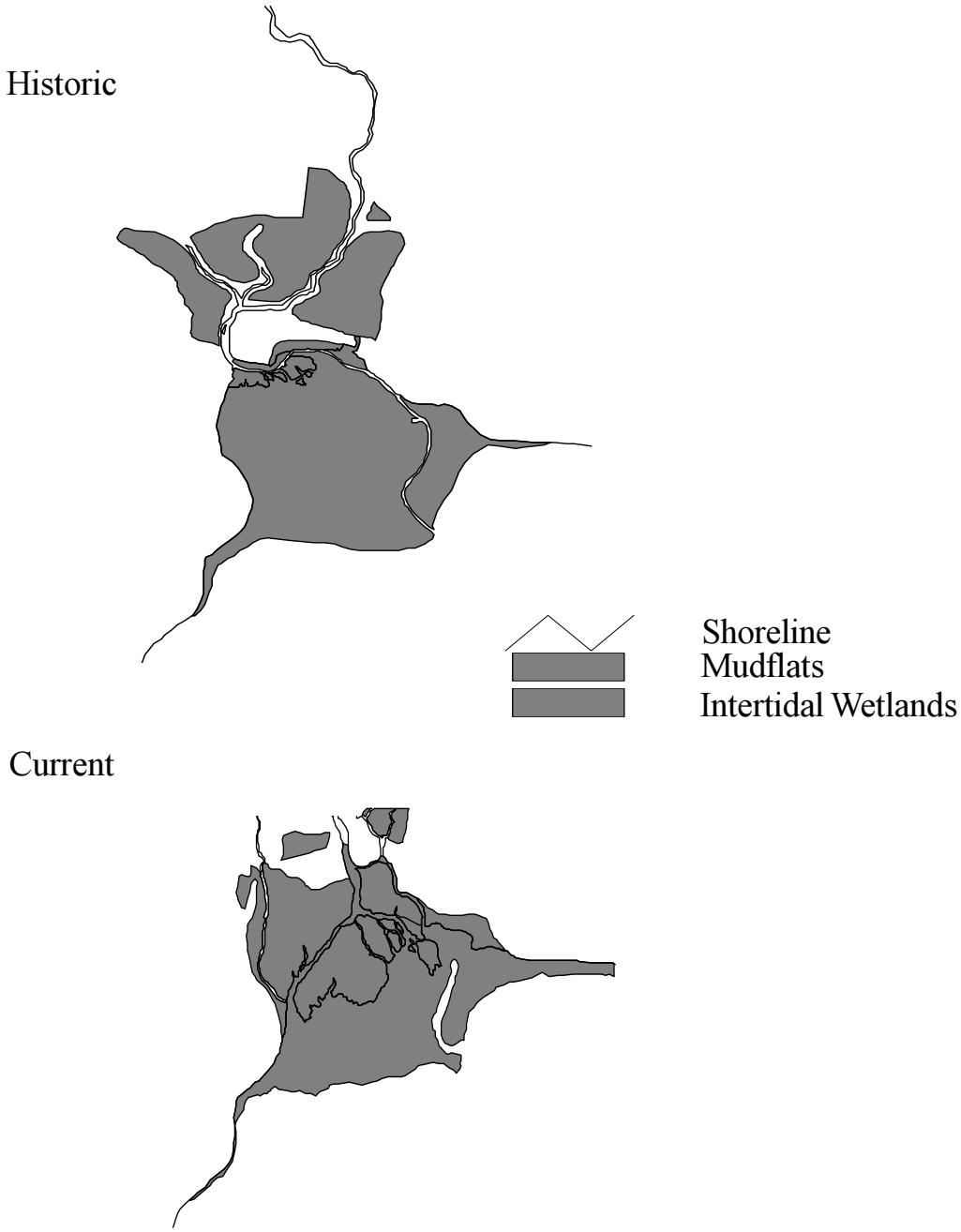

Figure 8. Historic and current estuarine conditions in Bellingham Bay (Bortleson 1979)

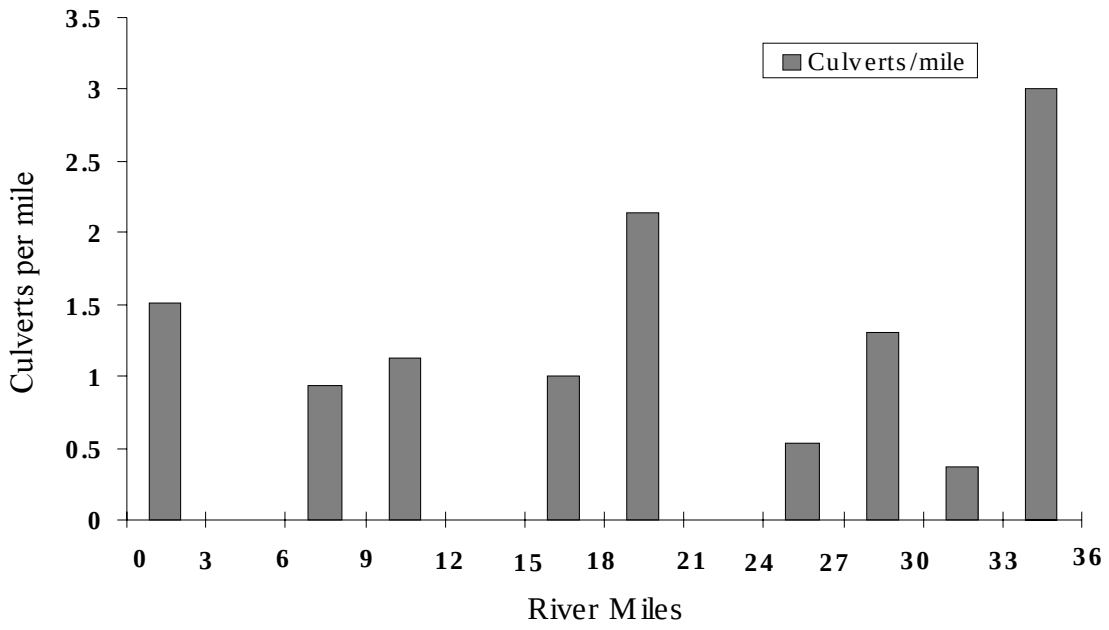

Figure 10. Culvert densities in Nooksack mainstrem and tributaries by river mile.

potential of the delta area of the Nooksack system from historic conditions.

Habitat degradation

Habitat degradation from such activities as ditching and channelization is widespread throughout the Nooksack River, but particularly in lowland tributaries (Figure 9). Over 20 miles of small tributary habitat that is tributary to the lower three miles of the Nooksack River are ditched. This compares to a total length of non-ditched habitat of approximately 36 miles. Thus approximately 36% of the smaller tributary habitat in this lower area has been severely physically altered. Between RM 6 and 9, approximately 14 miles of ditched habitat exist as compared to only 4.5 miles of non-ditched habitat, resulting in a total percentage of roughly 76% of all habitat in this area that has been severely degraded by physical alteration. Between RM 9 and 12, the most severe alteration has occurred in an area that historically contained the largest lengths of small tributary habitat. In this area, over 42 miles of small tributary habitat have been ditched, with only 25.5 miles remaining unditched. Between RM's 15 and 18, the amount of small tributary habitat is low with approximately 4 miles each of ditched and non-ditched habitat. No significant ditching has occurred above RM 18.

Based upon analysis of USGS topographic maps, we identified 767 culverts within the watershed. Of these, approximately 516 are located within the anadromous zone. Many smaller roads, such as logging roads, are not described on these maps so the total number of culverts is probably several times the number we identified. Assuming an average length of 66 feet for each culvert, there is an estimated minimum of 34,056 lineal feet, or 6.45 miles, of anadromous habitat within culverts. Although many culverts may be shorter than the assumed 66 feet, the total estimate is considered conservative due to the probably significant undercounting of the number of culverts. Approximately 2% of South Fork Nooksack pink salmon small tributary habitat is within culverts. Percentages for most other stocks are between 1% and 1.7%.

Culvert density, or the number of culverts per mile of stream, was generally constant within tributaries to the mainstem Nooksack between

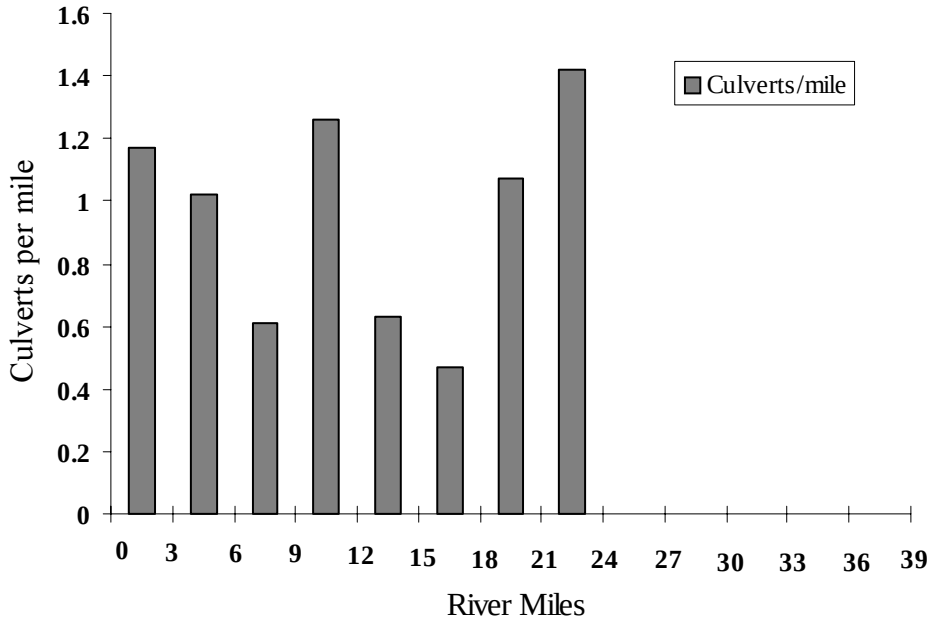

Figure 11. Culvert densities in North Fork and tributaries.

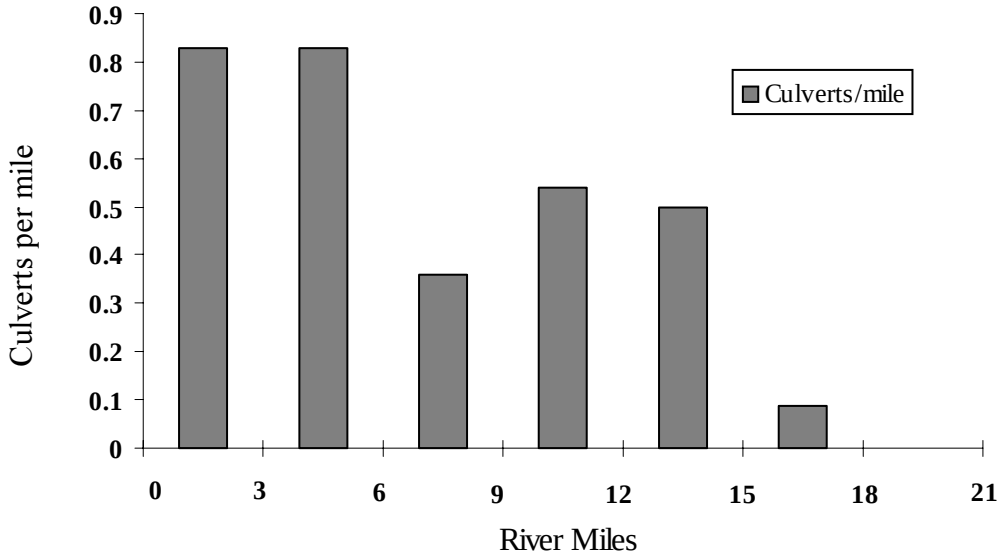

Figure 12. Culvert densities in Middle Fork and tributaries.

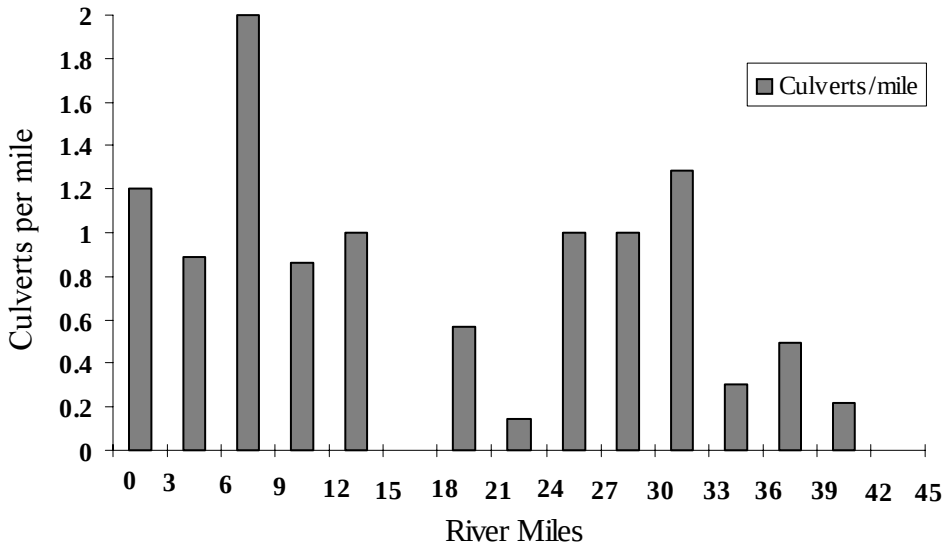

Figure 13. Culvert densities in South Fork and tributaries.

RM 0 and RM 36 (Figure 10). There was a generally decreasing trend in culvert density for the North Fork (Figure 11), Middle Fork (Figure 12), and South Fork (Figure 13) as one moves towards the headwaters. This decreasing trend is probably due to the change in land use from agriculture to forestry and National Forest. It may also be due to inaccurate depiction of the actual number of roads and culverts on the USGS topographic maps. Culvert density was calculated as an indicator of the level of disturbance from roads, and as a direct measure of the loss/degradation of habitat within culverts. It may also serve to assist in prioritizing areas within the Nooksack for further culvert assessment.

Water Quality

The water quality within the Nooksack system has been substantially degraded from historic conditions. The Washington Department of Ecology has identified 37 stream reaches or waterbodies within WRIA 1 that are water quality impaired. These include many tributaries, particularly in the lower portions of the watershed, as well as the mainstem Nooksack and Lummi Rivers and Bellingham Bay. These impaired waterbodies often exceed criteria for temperature, DO, sediment, and coliform. Common causes are agriculture, dairy, industry, urbanization, and forestry. Specific waterbodies and parameters exceeding standards are listed in Table 2.

Results by Stock

Species: Chinook
Stock: North Fork Nooksack
Origin and Type: Native/composite
Background: Data on this stock is very limited, however genetic data indicates native spawners are genetically distinct from other Puget Sound stocks (SASSI). Spawning escapements are thought to be less than 300 fish/year.
Status: Critical
Trend: Unknown
Timing: Spawn August through early September
Historical Distribution: Spawn in North Fork Nooksack above confluence with Middle Fork Nooksack; limited spawning in Maple, Canyon, Boyd, Cornel, and McDonald creeks.
Lost Habitat: None identified.
Obstructed Habitat: We did not identify any habitat in the North Fork mainstem or tributaries that has been blocked by obstructions. However, a significant amount of off-channel rearing habitat has been lost in the estuary area of the

Table 2. Water quality impaired waterbodies as listed on the WDOE 303d list (DOE 1996).

Water body Segment Number	Water body Name	Parameters Exceeding Standards
WA -01 -0010	Strait of Georgia	Temperature, Disolved Oxygen, PCB's, PAH, Fecal Coliform
WA - 01 - 0020	Drayton Harbor	Temperature, Disolved Oxygen, Ammonia - N, pH, Fecal Coliform
WA - 0100080	Bellingham Bay (outer)	Temperature, Dissolved Oxygen, Ammonia - N, pH
WA - 01 - 1002	Dakota Creek	Dissolved Oxygen, Fecal Coliform
WA - 01 - 1010	Nooksack River	Cromium, Mercury, Fecal Coliform
WA - 01 - 1012	Tenmile Creek	Ammonia - N, Dissolved Oxygen, Temperature, Fecal Coliform
WA - 01 - 1013	Kamm Slough	Dissolved Oxygen, pH, Fecal Coliform
WA - 01 - 1016	Morman Ditch	Dissolved Oxygen, pH, Fecal Coliform
WA - 01 - 1020	Nooksack River	Fecal Coliform
WA - 01 - 1030	Nooksack River SF	Fecal Coliform
WA - 01 - 1040	Nooksack River SF	Fine Sediment, Temperature
WA - 01 - 1060	Nooksack River MF	Temperature
WA - 01 - 1080	Nooksack River	Fine Sediment
WA - 01 - 1101	Silver Creek	Dissolved Oxygen, Fecal Coliform, Arsenic
WA - 01 - 1110	Bertrand Creek	Dissolved Oxygen, Fecal Coliform
WA - 01 - 1111	Duffner Creek	Dissolved Oxygen, Fecal Coliform
WA - 01 - 1115	Fishtrap Creek	Fecal Coliform
WA - 01 - 1116	Double Ditch Drain	Ammonia - N, Fecal Coliform
WA - 01 - 1117	Benson Road Ditch	Dissolved Oxygen Fecal Coliform
WA - 01 - 1118	Depot Road Ditch	Dissolved Oxygen, Fecal Coliform
WA - 01 - 1119	Bender Creek	Dissolved Oxygen, Fecal Coliform
WA - 01 - 1120	Anderson Creek	Fine Sediment
WA - 01 - 1145	Racehorse Creek	Fine Sediment, Temperature
WA - 01 - 1155	Boulder Creek	Temperature
WA - 01 - 1170	Cornell Creek	Temperature
WA - 01 - 1175	Gallop Creek	Temperature
WA - 01 - 1290	Howard Creek	Fine Sediment
WA - 01 - 1310	Canyon Lake Creek	Temperature
WA - 01 - 1450	California Creek	Dissolved Oxygen
WA - 01 - 2010	Sumas River	Dissolved Oxygen, Temperature, Fecal Coliform
WA - 01 - 2020	Johnson Creek	Dissolved Oxygen Fecal Coliform
WA - 01 - 2030	Sumas Creek	Fecal Coliform
WA - 01 - 2040	Pangborn Creek	Dissolved Oxygen, pH, Fecal Coliform
WA - 01 - 2050	Squaw Creek	Dissolved Oxygen, pH, Fecal Coliform
WA - 01 - 3110	Whatcom Creek	Temperature, Fecal Coliform, Pentachlorophenol
WA - 01 - 3300	Lummi River	Fecal Coliform
WA - 01 - 9170	Lake Whatcom	Total Phosphorus

Nooksack River (Figure 6). These losses include approximately 57 miles of obstructed small tributaries and 1.4 miles of distributary sloughs. These losses likely affect the growth and survival of juvenile outmigrant chinook salmon from the Nooksack River system.
Hydromodifications: Habitats used by NF Chinook have been significantly altered and affected by hydromodifications.

The Nooksack estuary, used by both returning adult chinook and by juvenile outmigrants, has been heavily modified (see section regarding estuarine habitat changes). It is likely that the loss of off-channel rearing, the blockage and the ditching of estuarine channels, the blockage of the Lummi River, the poor water quality, and the simplification of habitat due to agricultural, commercial, and residential activities has reduced the production potential of the Nooksack River in regards to NF Chinook salmon.

Upstream migration is potentially affected by poor water quality attributable to agricultural practices in the mainstem Nooksack and perhaps Bellingham Bay.

Habitats used for spawning and incubation have been affected by some channelization and diking along the North Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activities. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Species: Chinook
Stock: South Fork Nooksack
Background: Incomplete genetic data however samples indicate that stock is significantly different from other Puget Sound stocks. Escapement from 1984 to 1992 ranged from between 100 and 600 fish (SASSI).
Status: Critical
Origin and Type: Native/wild
Trend: Declining
Timing: September spawners
Historical Distribution: Stock spawns from RM 0.0 to RM 31.0 with most concentrated spawning between RM 14.0 and RM 30.4.
Lost Habitat: None identified
Obstructed Habitat: We did not identify any habitats in the South Fork or tributaries that have been blocked by obstructions. However, a significant amount of off-channel rearing habitat has been lost in the estuary area of the Nooksack River. These losses likely affect the growth and survival of juvenile outmigrant chinook salmon from the Nooksack River system.
Hydromodifications: Habitats used by SF Chinook have been significantly altered and affected by hydromodifications.

The Nooksack estuary, used by both returning adult chinook and by juvenile outmigrants, has been heavily modified (See Section regarding estuarine habitat changes). It is likely that the loss of off-channel rearing, blockage and ditching of estuarine channels, and blockage of the Lummi River, poor water quality, and simplification of habitat due to agricultural, commercial, and residential activities has reduced the production potential of the Nooksack River in regards to SF Chinook salmon.

Upstream migration is potentially affected by poor water quality in the mainstem Nooksack and perhaps Bellingham Bay.

Habitats used for spawning and incubation have been affected by some channelization and diking along the South Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activities. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Species: Chinook
Stock: Samish/Mainstem Nooksack
Background: This stock is non-native and thought to be mix of a number of Puget Sound chinook hatcheries. Data regarding natural spawners is not available.
Status: Unknown
Origin and Type: Non-native/composite

Trend: Unknown
Timing: Adults return during August and September with spawning in September and October.
Historical Distribution: Return to Samish hatchery and to mainstem spawning areas in Nooksack river.
Lost Habitat: None identified
Obstructed Habitat: We did not identify any habitats likely used by chinook in the mainstem Nooksack or tributaries that have been blocked by obstructions. However, a significant amount of off-channel rearing habitat has been lost in the estuary area of the Nooksack River. These losses likely affect the growth and survival of juvenile outmigrant chinook salmon from the Nooksack River system.
Hydromodifications: Habitats used by Samish/ Nooksack Chinook have been significantly altered and affected by hydromodifications.

The Nooksack estuary, used by both returning adult chinook and by juvenile outmigrants, has been heavily modified (See Section regarding estuarine habitat changes). It is likely that the loss of off-channel rearing, blockage and ditching of estuarine channels, and blockage of the Lummi River, poor water quality, and simplification of habitat due to agricultural, commercial, and residential activities has reduced the production potential of the Nooksack River in regards to NF Chinook salmon.

Upstream migration is potentially affected by poor water quality in the mainstem Nooksack and perhaps Bellingham Bay.

Habitats used for spawning and incubation have been affected by some channelization and diking along the mainstem Nooksack and Samish Rivers. Impacts from upstream forestry activities have probably reduced the quality of the natural spawning areas in the mainstem Nooksack River.

Species: Chum
Stock: North Fork Nooksack Fall
Background: Genetic tests indicate at least two sub-units in Kendall Creek and Maple Creek, and significant genetic differences from other Puget Sound stocks.
Status: Healthy
Origin and Type: Native/wild
Trend: Appear to be increasing.
Timing: Return from mid-October through mid-December. Spawn in November and December.
Historical Distribution: Spawn in mainstem North Fork Nooksack River and tributaries above confluence with Middle Fork Nooksack to around RM 62.0. Preferred spawning habitat in sloughs and braided channels between Welcome Creek (RM 41.0) and Kendall Creek (RM 46.0).
Lost Habitat: None identified
Obstructed Habitat: None identified
Hydromodifications: Some diking of the North Fork Nooksack river has occurred, particularly below RM 6. No distributary sloughs were identified as having been obstructed or lost, however the diking may have limited the formation of new side-channels used by chum. Spawning success is probably affected by sedimentation from natural and forestry related sources. A significant amount of road construction for forestry purposes has occurred in this sub-watershed.

Species: Chum
Stock: Mainstem/South Fork Nooksack Fall Chum
Background: No genetic or stock assessment data available.
Status: Unknown
Origin and Type: Native/wild
Trend: Unknown
Timing: Return in October and November with spawning in November and December.
Historical Distribution: Mainstem and South Fork Nooksack and tributaries (Hutchinson, Deer, and Fishtrap Creeks).
Lost Habitat: None identified
Obstructed Habitat: Several miles of side channel sloughs along the mainstem and South Fork Nooksack historically available for chum spawning, have been lost due primarily to diking in agricultural and residential areas. A large amount of small tributary habitat (~55 linear miles) and distributary sloughs (~2 miles) in the estuarine area has been obstructed, primarily by dikes, flood gates, and channelization.
Hydromodifications: The habitats historically used

by Mainstem/South Fork chum have been heavily altered by human activities. Much of the mainstem channels have been realigned, had gravel removed, and ditched. The effect of these activities on fish habitat tends to decrease the habitat diversity and reduce the amount of riparian vegetation.

Estuarine areas used by returning adults and by juvenile outmigrants have been affected largely by urbanization and agriculture. Major modification agents have been diking, dredging, and channelization. Water quality in the estuarine area is also poor due to agricultural runoff from growing urban and residential areas, upstream forestry activities, and industrial discharges, particularly in the lower mainstem Nooksack River.

Mainstem habitats have been affected by diking and channelization, primarily associated with agriculture.

Species: Chum
Stock: Samish/Independent drainages
Background: Genetic information indicates Samish hatchery fish are genetically distinct from other Puget Sound stocks but appear the result of mixing a number of hatchery stocks and perhaps native chum.
Status: Healthy
Origin and Type: Mixed/composite
Trend: Declining
Timing: Return and spawn October through December.
Historical Distribution: Mainstem Samish River and independent drainages.
Lost Habitat: No data
Obstructed Habitat: No data
Hydromodifications: No data

Species: Coho
Stock: Nooksack
Background: Stock is likely a product of native fish and hatchery fish from throughout the region extensively planted in the watershed prior to 1978. Hatchery plants from Nooksack hatchery continue. Some production of stock is apparently currently maintained through natural spawning.
Status: Unknown
Origin and Type: Mixed/composite
Trend: No discernible trend but highly variable.
Timing: Return September through October. Spawn late October through December.
Historical Distribution: Spawns and rears in all mainstem, forks, and tributaries of the Nooksack River system.
Lost Habitat: None identified
Obstructed Habitat: Approximately 25 miles of large and small tributary habitat have been obstructed throughout the Nooksack River system, not including the estuary area. Approximately 9 miles of coho habitat has been obstructed by the dam on the Middle Fork Nooksack. In other parts of the basin, obstructions are generally caused by culverts. In the estuary area, approximately 60 miles of small tributary habitat historically accessible to salmon has been obstructed by culverts, flood gates, and dikes.
Hydromodifications: Extensive modification of small tributary habitat in the lower river has dramatically changed the quality and quantity of coho habitat. Most low gradient unconfined small tributaries in the lower river and tributary to the mainstem, totally more than 60 miles in length, have been dredged, channelized, or ditched (Figures 8 & 9). Riparian vegetation along most of these channels has been cleared. Water quality is poor and erosion from upstream areas has severely degraded spawning and rearing habitat.

Species: Coho
Stock: Samish River
Background: Not known to be genetically distinct from other Nooksack or Puget Sound stocks. Stock is currently maintaining itself with natural production.
Status: Healthy
Origin and Type: Mixed/composite
Trend: Increasing
Timing: Return August through November with spawning September through December.
Historical Distribution: Samish River and tributaries. Samish hatchery.
Lost Habitat: No data
Obstructed Habitat: No data
Hydromodifications: No data

Species: Coho
Stock: North Puget Sound
Background: Data regarding this stock is poor. Stock delineated based on geographic spawning distribution. No genetic data available.
Status: Unknown
Origin and Type: Mixed/wild
Trend: No discernible trend but highly variable.
Timing: Return August through October with spawning in late October through December.
Historical Distribution: Independent North Sound drainage's and Samish River.
Lost Habitat: No data
Obstructed Habitat: No data
Hydromodifications: No data

Species: Pink
Stock: North Fork/Middle Fork Nooksack
Background: Spawning escapements between 1967 and 1991 ranged from 15,000 to 137,600. It is a distinct stock based on geographical distribution.
Status: Unknown
Origin and Type: Mixed/wild
Trend: No discernible trend but highly variable.
Timing: Return July through September with spawning in September.
Historical Distribution: North and Middle Forks of Nooksack River. High number of spawners in Thompson Creek.
Lost Habitat: None identified
Obstructed Habitat: The largest area of habitat obstructed within the range of North Fork and Middle Fork Nooksack pink salmon is located above the Middle Fork dam. However it is unknown whether pink salmon utilized this habitat historically.
Hydromodifications: North Fork pink have likely been affected by sedimentation from natural and forestry related sources. Some diking of the lower portions of the North Fork have occurred, however no lost or obstructed habitat was identified.
Middle Fork pinks are affected by flow fluctuations and low flows below the Middle Fork dam. No minimum instream flows are guaranteed below the dam which is operated for water supply and hydroelectric purposes.

Species: Pink
Stock: South Fork Nooksack
Background: There is very little data regarding South Fork Nooksack Pink stocks. Hutchinson Creek is the only spawning index stream on the South Fork and has experienced recent habitat degradation. No genetic information available. Thought to be native stock although North Fork stock appear genetically similar to Hood Canal hatchery stock (SASSI).
Status: Unknown
Origin and Type: Native/wild
Trend: Unknown
Timing: Return mid-June through mid-August, spawn in September and early October.
Historical Distribution: South Fork Nooksack up to RM 25.0 and in accessible tributaries.
Lost Habitat: None identified.
Obstructed Habitat: There is .3 miles of obstructed habitat identified for this stock. However, we identified 57 culverts which we had no data to support whether they were or were not passable. The amount of obstructed habitat could be greatly underestimated.
Hydromodifications: Habitats used for spawning and incubation have been affected by some channelization and diking along the South Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activities. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Species: Steelhead
Stock: South Fork Nooksack Summer Run
Background: A very small stock estimated to consist of fewer than 200 adults (SASSI)
Status: Unknown
Origin and Type: Native/wild
Trend: Unknown
Timing: Unknown
Historical Distribution: Upper reaches of the South Fork Nooksack
Lost Habitat: None identified
Obstructed Habitat: There was no obstructed habitat identified for this stock. However, we

identified 55 culverts which we had no data to support that there was or was not fish passage through them, and for this analysis we assumed that there was passage. The amount of obstructed habitat is likely and underestimate.
Hydromodifications: Habitats used for spawning and incubation have been affected by some channelization and diking along the South Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activities. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Species: Steelhead
Stock: Nooksack/Samish – Dakota Creek Winter Run
Background: The stock is comprised of a historically small number of adults, but stock status is Unknown (SASSI)
Status: Unknown
Origin and Type: Native/wild
Trend: Unknown
Timing: Return to river from November through March.
Historical Distribution: Dakota Creek, its forks, and tributaries.
Lost Habitat: No data
Obstructed Habitat: No data
Hydromodifications: No data

Species: Steelhead
Stock: Nooksack/Samish – Mainstem/North Fork Nooksack Winter Run
Background: Poor water visibility conditions in mainstem limit spawning ground survey data.
Status: Unknown but appears depressed
Origin and Type: Native/wild
Trend: Declining
Timing: Return to river December through April, spawn March through June.
Historical Distribution: Assumed to be same as current distribution.
Lost Habitat: None identified
Obstructed Habitat: There are 2 miles of small tributary habitat obstructed by culvert on Kenny Creek.
Hydromodifications: Habitats used for spawning and incubation have been affected by some channelization and diking along the North Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activities. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Extensive modification of small tributary rearing habitat in the lower river has dramatically changed the quality and quantity of steelhead habitat. Most low gradient unconfined small tributaries in the lower river and tributary to the mainstem, totaling more than 60 miles in length, have been dredged, channelized, or ditched (Figures 9 & 10). Riparian vegetation along most of these channels has been cleared. Water quality is poor and erosion from upstream areas has severely degraded spawning and rearing habitat.

Species: Steelhead
Stock: Nooksack/Samish – South Fork Nooksack Winter Run
Background: Information regarding mainstem spawning is limited due to high turbidity during spawning period.
Status: Unknown
Origin and Type: Native/wild
Trend: Unknown
Timing: Spawning occurs between mid-February and mid-June.
Historical Distribution: Assumed to be similar to current distribution.
Lost Habitat: None identified
Obstructed Habitat: There was no obstructed habitat identified for this stock. However, we identified 55 culverts which we had no data to support that there was or was not fish passage through them, and for this analysis we assumed that there was passage. The amount of obstructed habitat is likely and underestimate.
Hydromodifications: Habitats used for spawning and incubation have been affected by some channelization and diking along the South Fork. It is likely however that the most significant impact to spawning areas has been due to forestry activi-

ties. Forest practices have had the following effects: increased slope instability, increases in sedimentation, the decrease in canopy cover, changes in hydrology, and increased channel scour associated with higher peak flows.

Species: Steelhead
Stock: Nooksack/Samish – Middle Fork Nooksack Winter Run
Background: Information regarding mainstem spawning is limited due to high turbidity during spawning period.
Status: Unknown
Origin and Type: Native/wild
Trend: Appears to be declining
Timing: Return in November and December, spawn in March and April.
Historical Distribution: Middle Fork Nooksack and tributaries up to the diversion dam at RM 7.2.
Lost Habitat: None identified
Obstructed Habitat: At RM 7.2, the Middle Fork diversion dam obstructs approximately 7.3 miles of mainstem habitat and 12.3 miles of small tributary habitat.
Hydromodifications: Middle Fork Steelhead are affected by flow fluctuations and low flows below the Middle Fork dam. No minimum instream flows are guaranteed below the dam which is operated for water supply and hydroelectric purposes.

Species: Steelhead
Stock: Samish Winter Run
Background: Stock assumed to be distinct due to geographic location (SASSI)
Status: Depressed
Origin and Type: Native/wild
Trend: Declining
Timing: Return November through March, spawn February through June
Historical Distribution: Samish River and tributaries.
Lost Habitat: No data
Obstructed Habitat: No data
Hydromodifications: No data

Restoration recommendations

Due to the large size of the Nooksack River basin and the relatively course resolution of our analysis, we believe that it is not appropriate at this time to recommend site specific restoration projects or priorities. However, several restoration needs are evident based on our assessment of habitat quality and quantity. These are:

- Restore blocked small tributary habitat in the lower river.
- Restore habitat quality and complexity in small tributary habitats in mainstem river tributaries.
- Restore access to large and small tributary habitat obstructed by Middle Fork dam.
- Take actions to restore or improve water quality in mainstem and small tributaries to mainstem.
- Restore riparian vegetation, particularly in mainstem and mainstem small tributaries.

Data Gaps

To date, we have identified only two blocking culverts within the watershed outside of the estuary area.. This low number is probably more indicative of the lack of detailed information regarding culverts and their fish passage characteristics than of the actual number of culverts acting as barriers to fish passage. We have no information regarding culverts that may be blocking passage of upstream-migrating juvenile salmonids into off-channel winter rearing habitats.

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